United States
Environmental Protection
Agency

EPA/540/MR-92/011
March 1992

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Demonstration Bulletin

Cyclone Furnace Soil Vitrification Technology

Babcock & Wilcox

Technology Description: Babcock and Wilcox's (B&W) cyclone furnace is an innovative thermal technology which may offer advantages in treating soils containing organics, heavy metals, and/or radionuclide contaminants. The furnace used in the SITE demonstration was a 4- to 6-million Btu/hr pilot system. The test facility, shown in Figure 1, is fired by a scaled-down version of B&W's commercial cyclone furnace. It is water-cooled and simulates the geometry of B&W's single cyclone, front-wall-fired cyclone boiler. This furnace is typical of full-scale, coal-fired cyclone units in regard to furnace/convection gas temperature profiles and residence times, NO_x levels, cyclone slagging potential, ash retention in the slag, unburned carbon and flyash particle size.

For the demonstration, natural gas was introduced into the cyclone furnace. Preheated combustion air (nominal 800°F) enters tangentially into the cyclone furnace. The soil is introduced via a soil disperser (nozzle) at the center of the cyclone. The gas temperature out of the cyclone barrel is over 3000°F while the gas exiting the furnace has a temperature over 2000°F with a 2 sec residence time.

The cyclone is designed to achieve very high heat release rates, temperatures and turbulence. Particulate matter from the soil stream is retained along the walls of the furnace by the swirling action of the combustion air and is incorporated into the molten slag layer. Organic material in the soil is vaporized or incinerated in the molten slag. The slag which has a temperature of 2400°F exits the cyclone furnace from a tap at the cyclone throat and drops into a water-filled tank where the material is quenched. A small portion of the soil exits as flyash with the flue gas from the furnace and is collected in a baghouse. A heat exchanger cools stack gases to approximately 200°F before they enter the baghouse.

Waste Applicability: This furnace can treat liquids, sludges, or soils contaminated with organics, heavy metals and/or radionuclides.

Demonstration Results: The demonstration took place at B&W's Alliance Research Center in Alliance, OH between November 4, 1991 and November 16, 1991. The process was demonstrated using a Synthetic Soil Matrix (SSM) provided by EPA's Risk Reduction Engineering Laboratory in Edison, NJ. SSMs are well-characterized, clean soils which are spiked with known concentrations of contaminants of concern. For this study, the SSM was spiked with heavy metals (cadmium, chromium and lead); semi-volatile organics (anthracene and dimethyl phthalate); and simulated radionuclides (bismuth, strontium and zirconium). Simulated radionuclides are non-radioactive metals whose behavior in the cyclone furnace will simulate true radionuclide species.

Three replicate tests were conducted at B&W's pilot facility. SSM was fed into the cyclone at 170 lb/hr. The total amount of SSM

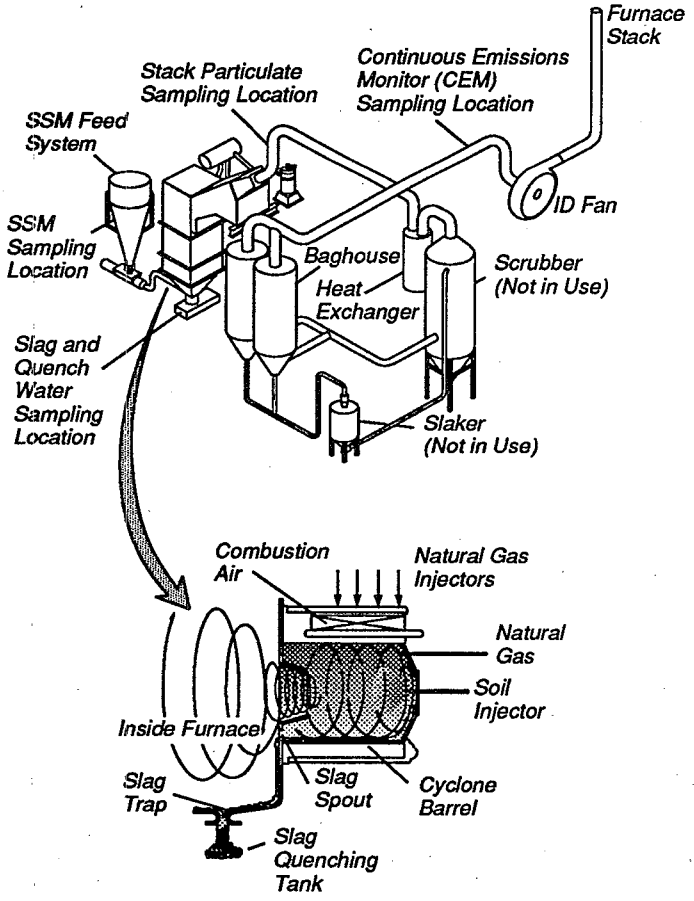

Figure 1. *Cyclone Test Facility*

treated during the three runs was about 1 ton; the total amount burned during the entire demonstration was almost 3 tons. A review of preliminary data reflects the following results:

- The slag produced complied with TCLP regulatory requirements. Average leachate concentrations for cadmium, chromium, and lead were 0.1, 0.3 and 0.7 mg/L, respectively.
- A 12 to 1 weight ratio of slag to flyash was achieved.
- Almost 95% of the non-combustible portion of the SSM was incorporated within the slag. On average, over 75% (by weight) of the chromium in the SSM was trapped in the vitrified slag. In addition, the percentages for strontium and zirconium retained in the slag were 85% and 95%, respectively. The other metals in the SSM (bismuth, cadmium, and lead) are considered "volatile" and lower percentages of these metals were retained in the slag.
- Metals which partitioned to the flue gas were captured by the baghouse. Since the resulting baghouse solids failed TCLP for cadmium and chromium, the baghouse solids were treated as a hazardous waste. Approximately 150 lb of baghouse solids were collected during the entire demonstration.
- The volume of slag produced was 28% smaller than the feed SSM.
- Destruction and Removal Efficiencies (DREs) for both semivolatile organic spikes were greater than 99.99%.
- An average of 0.001 grains per dry standard cubic foot of particulate (corrected to 7% O_2) was emitted, which is less than the RCRA regulatory limit of 0.08 grains per dry standard cubic foot at 7% O_2.
- The average flue gas flow rate out the stack was 1250 dry standard cubic feet per minute. The average exhaust gas composition from the burning of SSM and natural gas was approximately 5.6% O_2, 8.6% CO_2, 359 ppm NO_x, 6 ppm CO, and 8.4 ppm total hydrocarbons (measured as propane).
- The simulated radionuclides were immobilized within the slag according to American Nuclear Society Method 16.1.
- The process formed products of incomplete combustion; however, concentrations were very low.

An Applications Analysis Report and a Technical Evaluation Report describing the complete demonstration will be available in the Fall of 1992.

For Further Information:

EPA Project Manager:
Laurel Staley
U.S. EPA Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
(513) 569-7863 (FTS: 684-7863)

United States
Environmental Protection
Agency

Center for Environmental
Research Information
Cincinnati, OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

Official Business
Penalty for Private Use $300

EPA/540/MR-92/011